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Comparative Effects of Weight Loss Associated with a Consistent Volume of Exercise Within Education-Focused vs. Self-Regulation-Focused Obesity Treatments in Women

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Abstract

Although exercise is generally included in behavioral weight-management treatments, its association with weight loss cannot be reconciled by its corresponding energy expenditures in formerly low-active adults with obesity. It has been suggested that the self-regulation needed to maintain exercise carries over to more controlled eating (i.e., coaction) and weight loss, with exercise-associated mood improvements also having positive impacts on eating behaviors and weight. To clarify these findings to improve behavioral interventions, women randomly assigned to community-based obesity treatments with either a self-regulation focus (n = 40) or educational focus (n = 25) were included in the present reanalysis of recent data. A requirement for inclusion within the present study was completion of 2 to 5 moderate exercise sessions per week (retrospectively assessed), regardless of treatment condition. Demographic data, weight, self-regulation, and negative mood did not significantly differ, by group, at baseline. Only reduction in weight significantly differed over 6 months, with a more pronounced improvement in the self-regulation-focused group. Changes in both self-regulation and negative mood significantly mediated the relationship between group and weight loss. Further regression analysis indicated that the entry of group significantly added to the prediction of weight change by (a) both self-regulation and mood change, and (b) change in self-regulation alone. For the present adherents to a moderate amount of exercise, improvements in self-regulation and mood explained a considerable amount of the variance (32%–37%) in weight loss over 6 months. However, analyses of effects from additional, possibly related, psychosocial variables based on theory and/or prior research (e.g., self-efficacy, emotional eating) will expand understandings of the value of moderate exercise beyond associated energy expenditures within varied behavioral obesity-treatment foci.

Keywords

obesity, intervention, weight, mood, behavioral, psychosocial

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Abstract

Although exercise is generally included in behavioral weight-management treatments, its association with weight loss cannot be reconciled by its corresponding energy expenditures in formerly low-active adults with obesity. It has been suggested that the self-regulation needed to maintain exercise carries over to more controlled eating (i.e., coaction) and weight loss, with exercise-associated mood improvements also having positive impacts on eating behaviors and weight. To clarify these findings to improve behavioral interventions, women randomly assigned to community-based obesity treatments with either a self-regulation focus (n = 40) or educational focus (n = 25) were included in the present analysis of data. A requirement for inclusion in the present study was completion of two to five moderate exercise sessions per week (retrospectively assessed), regardless of treatment condition. Demographic data, weight, self-regulation, and negative mood did not significantly differ, by group at baseline. Only reduction in weight significantly differed over six months, with a more pronounced improvement in the self-regulation-focused group. Changes in both self-regulation and negative mood significantly mediated the relationship between group and weight loss. Further regression analysis indicated that the entry of group significantly added to the prediction of weight change by (1) both self-regulation and mood change, and (2) change in self-regulation alone. For the present adherents to a moderate amount of exercise, improvements in self-regulation and mood explained 32% to 37% of the variance in weight loss over six months. However, analyses of effects from additional, possibly related, psychosocial variables based on theory and/or prior research (e.g., self-efficacy, emotional eating) will expand understanding of the value of moderate exercise beyond associated energy expenditures within varied behavioral obesity-treatment foci.

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Introduction

Obesity treatments with their bases in behavioral rather than surgical or pharmacological methods have been largely unsuccessful at weight loss beyond their initial several weeks or months (Dombrowski et al., 2014). However, exercise has been a consistent and productive intervention component (Donnelly et al., 2004). Exercise has been incorporated in obesity treatments in ways ranging from an optional adjunct to severe eating changes, to mandating extreme (often aversive) amounts, to encouraging moderate volumes to augment compliance with energy-intake restrictions (Annesi, 2022). Proposed reasons why exercise benefits sustained weight loss are varied and inconclusive. Common beliefs related to exercise's effect on kilocalorie (kcal) expenditure and metabolism are problematic because those factors explain only a minimal portion of the variance in weight change in formerly low-active adults with obesity (Hopkins et al., 2014).

Psychological/behavioral explanations of the exercise-weight loss relationship suggest maintained exercise (of even moderate

amounts) requires self-regulating through lifestyle barriers and challenges that can carry over to controlled eating and weight loss (Annesi, 2022). This process of generalization of changes across health behaviors is referred to as "coaction," and is thought to involve self-regulatory processes such as cognitive reappraisal, self-monitoring, and stimulus control (Johnson et al., 2014). Research indicates the central role self-regulation plays in individuals overcoming common lifestyle barriers such as slow progress, social pressures discouraging productive behaviors, and discomfort that predict early failure at weight loss (Annesi, 2022). Also, even the modest amount of exercise of 2.5 to 3.0 moderate-intensity sessions per week has been associated with improved mood, with no (exercise) dose-(mood improvement) response effect (Annesi, 2021; Arent et al., 2020). Exercise-associated improvements in mood have been linked to reductions in emotion-driven eating and weight loss (Thayer, 2001). Impacts from self-regulation and mood on the sustained behavioral changes required for significant weight loss are consistent with social cognitive theory (Bandura, 1986), and sometimes have been leveraged in theory-driven obesity treatments (Annesi, 2022). However, approaches that simply educate on the need for exercise and healthy eating predominate (Powell et al., 2007). Weight change effects from curriculum-based self-regulation and/or mood improvements associated with moderate amounts of exercise are unclear.

To add to the extant research on relationships between exercise and psychological changes in a manner that can impact both weight-loss theory and treatment architectures, a small-scale reanalysis of field-based data was completed and is reported upon here. Specifically, to address the aims of the present research, women participating in community-based obesity treatments with emphases on self-regulation skills development or weight-loss education, completing a consistent (moderate) amount of exercise, were assessed over six months. The moderate amount of exercise required across treatment conditions facilitated group contrasts based on changes in the psychological variables of interest rather than via possible differences in exercise outputs. Women were selected for this study for the following reasons: (1) they are the most frequent participants in weight-loss programs (Crane et al., 2017); (2) previous analyses of obesity treatments have not controlled well for completed exercise amounts in women (which varies greatly due to their challenges of adhering to exercise; e.g., Trost et al., 2002); and (3) effects of mood in weight-loss contexts are more pronounced in women (Péneau et al., 2013), thereby warranting their separate analyses.

One could expect that the group emphasizing self-regulation would have greater increases on that factor. Because exercise (including a minimum required amount) was held consistent in the analyses, one could expect that mood improvements would be similar across groups. It also was posited that improvements in self-regulation and mood would have a significant positive association with weight loss; however, treatment-specific effects beyond those associations were unclear. One can hope that the present research helps to elucidate the psychosocial bases of the effects of exercise on weight loss, while accounting for differences in obesity treatment foci.

Methods

Participants and Procedure

This study is a secondary analysis of data from United States-based field research that investigated behavioral obesity-management methods in community-based settings

(Annesi, 2022). Inclusion criteria were: (1) women of at least 21 years-of-age with obesity (body mass index [BMI] $\geq$ 30 kg/m^2), (2) reporting $\leq$ 2 exercise sessions per week at baseline, and (3) a Leisure-Time Physical Activity Questionnaire (Godin, 2011) score between 30 and 75 over six months. This score is equivalent to two to five moderate sessions per week. Additional criteria were no medical contraindication for participation, no present/soon-planned pregnancy, and no change in a prescribed psychotropic medication during the previous six months. Group assignment in the original data set was by simple randomization. For participants meeting the inclusion criteria, characteristics in the education-focused group (n = 25) and the self-regulation-focused group (n = 40) did not significantly differ at baseline. Both treatments were administered in a combination of office, conference room, and phone settings by community health-promotion instructors with at least one national certification and training in one of the treatment protocols.

The self-regulation-focused condition consisted of five, one-on-one sessions (50 minutes each) over the initial four months. They primarily focused on building participants' self-regulatory skills (e.g., goal setting, progress tracking, relapse prevention, stimulus control, cognitive restructuring) to address lifestyle barriers/challenges to completing regular exercise. A final summary session supporting exercise occurred at Month 6. To address eating behavior change, small group sessions began at Month 3 and consisted of eight 50-minute meetings. They primarily concentrated on adapting the already-covered self-regulatory skills, but for controlled eating. They also ended at Month 6.

The education-focused condition informed participants on standard exercise and healthy eating content through an initial face-to-face meeting of 20 minutes. That meeting also briefly overviewed basics of the 12 readings that were individually distributed to the participants over the next six months (e.g., "Convenient exercise options," "Ways to increase fruits and vegetables"). Those readings that were provided at two-week intervals via either electronic or paper means (based on each participant's preference), each required approximately 40 minutes to complete. Each of the required readings was followed-up in two to four days by a one-on-one in-person or phone interaction of 10 to 15 minutes to increase clarity of their content.

Both treatment conditions required approximately 11 hours from participants over six months. Common to both were: (1) reference to the governmental recommendation of at least 150 minutes/week of moderate-intensity exercise/physical activity for health, (2) the value of increasing fruit and vegetable consumption, and (3) limiting energy intake to 1200 to 1500 kcal per day (based on current weight). Non-instructor staff administered structured fidelity checks on 15% of treatment sessions (indicating strong protocol compliance by instructors). They also completed in-private measurement of study variables at baseline and Month 6 (also at Month 3 for exercise).

Measures

Self-regulating eating was measured by ten items derived from a taxonomy of social cognitive theory-driven self-regulatory techniques (Michie et al., 2011). Each item, such as "I make formal agreements with myself regarding my eating" had a response option ranging from 1 (*never*) to 4 (*often*). They were summed. The reported internal consistency was Cronbach's α = .81, and two-week test-retest reliability was .74 (Annesi & Marti, 2011). Predictive validity was indicated through score associations with

weight change (Annesi & Marti, 2011). In the present sample, $\alpha = .75$.

Negative mood felt over the previous seven days was measured by the 30-item Profile of Mood States-short form (McNair & Heuchert, 2009). Dimensions of anxiety, depression, confusion, anger, fatigue, and vigor were represented via items such as "sad," "anxious," and "vigorous." Response options for each item ranged from 0 (*not at all*) to 4 (*extremely*) and were summed. The vigor-related items were first reverse-keyed. In women, the reported internal consistency was Cronbach's $\alpha = .90$, and three-week test-retest reliability averaged .70 (McNair & Heuchert, 2009). Concurrent validity was demonstrated through score correspondences with accepted scales such as the Beck Depression Inventory and Manifest Anxiety Scale (McNair & Heuchert, 2009). In the present sample, $\alpha = .86$.

Body weight was measured by study staff to the nearest 0.10 kg using a calibrated digital floor scale (Health-o-meter, Professional 800KL, Atlanta, GA). Participants first removed their shoes and any heavy outer-clothing such as a jacket.

Exercise completed during the previous week (7 days) was measured by the Leisure-Time Physical Activity Questionnaire (Godin, 2011). Recalled number of sessions of at least 15 minutes were converted into metabolic equivalents (METs, a measure of energy expended during an activity) ranging from "mild" (e.g., easy walking; 3 METs) to "strenuous" (e.g., running; 9 METs). These values were multiplied by their respective frequencies and then summed. Concurrent validity was supported by reported correspondences with VO_{2max} stress test and accelerometer results, with two-week test-retest reliability at .74 (Godin, 2011; Pereira et al., 1997). Weekly scores on the Leisure-Time Physical Activity Questionnaire were classified by its developer as follows: 13 or less = "low," 14-23 = "moderate," and 24 or greater = "active" (Godin, 2011).

Data Analysis

Established criteria (White et al., 2011) indicated no systematic bias in participants with versus without missing cases in the 8% of missing data (i.e., missing-at-random). This made suitable application of the expectation-maximization algorithm for imputation (Little & Rubin, 2014) and facilitation of an intention-to-treat format. Considering the primary regression analysis incorporating two independent variables predicting weight change and an expected moderate effect size of Cohen's $f^2 = .20$ obtained from related research (Annesi, 2022), an overall sample size of 51 was required at the statistical power of .80 (Cohen, 1988). Acceptable multicollinearity was indicated through variance inflation factor scores < 2.0. Statistical significance was set at $\alpha < .05$ (2-tailed), throughout. SPSS Version 28.0 was used for the statistical testing, incorporating the Process 4.1 macro-instructional Model 4 with 20,000 percentile method-based bootstrapped resamples (Hayes, 2018).

One-way ANOVA and χ^2 analyses first assessed group differences/consistencies in exercise, and demographic and study variables, at baseline. One-way ANOVA additionally assessed group difference in exercise when baseline, Month 3, and Month 6 scores were aggregated. To address group differences in gain (change) scores, mixed-model repeated measures ANOVAs assessed overall significance of changes in weight, self-regulation, and negative mood from baseline to Month 6; and each corresponding time × group interaction. Associated effect sizes were calculated using partial eta-squared ($\eta^2_{partial}$).

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Table 1
Descriptive statistics and change scores by group

Measure / Group	Baseline *M*	Baseline *SD*	Month 6 *M*	Month 6 *SD*	Change from baseline-Month 6 *M*	Change from baseline-Month 6 *SD*	*d*
Self-regulating eating							
Self-regulation-focused	19.30	4.36	25.57	3.20	6.27	4.38	1.43
Education-focused	19.42	4.08	22.75	3.70	3.33	4.16	0.80
Aggregated data	19.35	4.22	24.49	3.65	5.14	4.50	1.14
Negative mood							
Self-regulation-focused	22.78	15.23	4.66	11.82	-18.11	16.00	1.13
Education-focused	19.72	11.90	10.92	10.81	-8.80	9.94	0.89
Aggregated data	21.60	14.03	4.07	11.76	-14.53	14.62	0.99
Weight (kg)							
Self-regulation-focused	95.97	11.35	89.96	11.90	-6.27	4.38	1.47
Education-focused	98.32	10.92	95.81	11.51	-2.51	3.03	0.83
Aggregated data	96.87	11.16	92.21	12.01	-4.66	4.07	1.15

Note.
Self-regulation-focused group n = 40. Education-focused group n = 25. Aggregated data N = 65.
d = Cohen's measure of effect size for within-group change.

Next, the linear bivariate prediction of weight change by group (coded, 0 = education-focused group, 1 = self-regulation-focused group) was assessed. To evaluate the additional role of changes in self-regulation and mood, mediation of changes in self-regulation and mood on the group → weight loss relationship was next assessed via a parallel mediation model. Because of the use of bootstrapping, significance of mediation was assessed via a 95% confidence interval (95% CI) (Hayes, 2018).

To appraise the portion of the variance in weight loss explained exclusively by group treatment processes (including beyond the identified changes in self-regulation and negative mood), supplementary sensitivity analyses were conducted. Specifically, group was entered into Step 2 of a stepwise multiple regression model where changes in self-regulation and negative mood were simultaneously entered as predictors of weight change in Step 1. Because only self-regulation was distinctly addressed in treatment, the same model was calculated with self-regulation change as the sole mediator.

Results

Between-Group Consistencies

There were no significant group difference (*dfs* = 1, 63) at baseline on age (overall M = 47.32 years, SD = 8.31), F = 3.64, p = .061; BMI (overall M = 35.30 kg/m^2, SD = 3.37), F = 1.85, p = .179; race/ethnicity (overall 77% white, 14% black, 7% Hispanic, 2% other), $\chi^2(3) = 1.71$, p = .635; self-regulation, F = 0.01, p = .909; negative mood, F = 0.73, p = .397; weight, F = 0.68, p = .413; or exercise, F = 0.004, p = .951 (Table 1). There also were no significant differences by group, on exercise aggregated across baseline, Month 3, and Month 6 (overall M = 65.76, SD = 23.74), F = 2.63, p = .110.

Table 2
Prediction of weight change by changes in self-regulation and mood (N = 65)

	B	SE_B	β	p	95% CI
Model 1					
Step 1 $R^2 = .32$, $p < .001$					
Change in self-regulating eating	-0.38	0.10	-.41	<.001	-0.57, -0.18
Change in negative mood	0.08	0.03	.30	.008	0.02, 0.14
Step 2 $R^2 = .37$, $p < .001$					
Change in self-regulating eating	-0.32	0.10	-.35	.002	-0.52, -0.12
Change in negative mood	0.07	0.03	.24	.033	0.01, 0.13
Group	-1.95	0.92	-.23	.039	-3.79, -0.10
Model 2					
Step 1 $R^2 = .24$, $p < .001$					
Change in self-regulating eating	-0.44	0.10	-.49	<.001	-0.64, -0.24
Step 2 $R^2 = .32$, $p < .001$					
Change in self-regulating eating	-0.36	0.10	-.39	<.001	-0.56, -0.16
Group	-2.46	0.92	-.30	.010	-4.30, -0.62

Note.
Group was coded: 0 = education-focused group, 1 = self-regulation-focused group. *B* = unstandardized beta; *SE* = standard error; β = standardized beta. 95% CI = 95% confidence interval.

Contrasts of Score Changes

There were significant overall improvements (*dfs* = 1, 63) in weight, $F = 80.60$, $p < .001$, $\eta^2_{partial} = 0.56$; self-regulation, $F = 2851.60$, $p < .001$, $\eta^2_{partial} = 0.98$; and negative mood, $F = 112.54$, $p < .001$, $\eta^2_{partial} = 0.64$. There was a significant time × group interaction (*dfs* = 1, 63) in favor of the self-regulation-focused group on weight, $F = 94.29$, $p < .001$, $\eta^2_{partial} = 0.18$; but no significant group difference on change in self-regulation, $F = 2.73$, $p = .103$, $\eta^2_{partial} = 0.18$; or negative mood, $F = 0.34$, $p = .561$, $\eta^2_{partial} = 0.01$. Table 1 shows descriptive statistics and change scores.

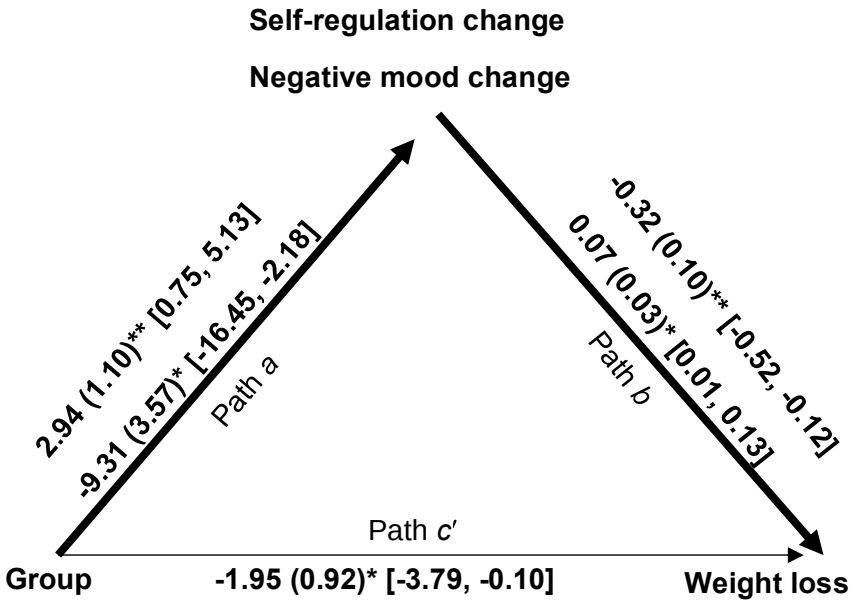
Effects of Group on Weight Loss

In the linear bivariate analysis, weight loss was significantly predicted by group membership, B = -3.50, $SE_B = 0.95$, $\beta = -.42$, $p < .001$, 95% CI [-5.40, -1.61], $R^2 = .18$. Both change in self-regulation, B = -0.94, $SE_B = 0.44$, 95% CI [-1.86, -0.12], and change in negative mood, B = -0.61, $SE_B = 0.37$, 95% CI [-1.45, -0.02] significantly contributed to mediation of the prediction of weight loss by group membership, $R^2 = .37$, $F(3, 61) = 11.73$, $p < .001$. Figure 1 shows the path relationships for the mediation model.

Effects of Changes in Self-regulation and Mood on Weight Loss

In a sensitivity analysis incorporating multiple regression models, change in self-regulation and negative mood each significantly contributed to the prediction of weight change (Table 2, Model 1). Entry of group in Step 2 of the model significantly increased the associated R^2 by .05, $F_{change} = 4.44$, $p = .039$. All three predictors

Figure 1
Mediation model data



Note.
Change scores are from baseline to Month 6. Path data are given as unadjusted beta, (its associated standard error), and [95% confidence interval].
*$p < .05$. **$p < .01$.

significantly contributed to the explained variance in weight change (Table 2, Model 1). In a second multiple regression equation, change in self-regulation significantly predicted weight change (Table 2, Model 2). Entry of group in Step 2 significantly increased the associated R^2 by .08, F_{change} = 7.13, p = .010. Both predictors significantly contributed to the explained variance in weight change (Table 2, Model 2).

Discussion

This purpose of this study was to assess weight change, and its prediction by changes in self-regulation and mood, in women participating in different obesity treatment curricula but completing a similar (moderate) amount of weekly exercise. Key findings were that changes in self-regulating eating and negative mood significantly mediated the effects of group (self-regulation-focused versus educationally focused) on weight loss over six months. Also, both self-regulation and mood changes significantly contributed to the explained variance in weight loss, even when group was controlled. Effect sizes on improvements in self-regulating eating, mood, and weight were large and very large for the education-focused and self-regulation-focused groups, respectively. However, only weight reduction was significantly more pronounced in the self-regulation-focused condition.

These findings are consistent with research that primarily assessed self-regulation and/or mood as a predictor of weight loss in a cross-sectional manner or failed to account for the effects of exercise amounts on psychological predictors of exercise (Andrade et al., 2010; Teixeira et al.,

2010). However, findings did not align with research that suggests that amounts of exercise far in excess of those within this investigation are required for meaningful amounts of weight loss (Donnelly et al., 2009). Much of that line of research viewed exercise for its direct impact on weight via its energy-expenditure properties, as opposed to its associated psychosocial and self-regulatory improvements that might foster sustained behavioral improvements and long-term weight loss (Annesi et al., 2022; Teixeira et al., 2010). As with the present study, much of the previous related research was with women participants who are more likely to access behavioral weight-loss treatments (Crane et al., 2017) and be more impacted by the psychological effects of eating and weight (Péneau et al., 2013).

Whereas moderate exercise-associated improvements in self-regulation and mood significantly impacted weight loss over six months in the present sample (Paths b, Figure 1), additional (yet unidentified) effects (presumably of a psychosocial nature because demographic factors and exercise amounts were controlled) remained to be ascertained. Those were likely accountable via the different treatment foci. Assessment of treatment-associated changes in related factors that were previously proposed as relevant (e.g., self-efficacy through effects of self-regulation on perceived ability; emotional eating through effects on negative mood; Annesi & Walsh, 2021; Teixeira et al., 2010) might be productive in extensions of this research. This is particularly true given the associations with both self-regulation and mood that occurred in favor of the self-regulation-focused group (Paths a, Figure 1), and beyond exercise itself.

To summarize implications from this study, and in agreement with other research (Annesi, 2010, 2021, 2022; Teixeira et al., 2010), exercise in moderate amounts appears important for weight loss because of its association with self-regulation, mood, and other yet-to-be identified psychosocial factors; and a treatment focus on self-regulation rather than education might better encourage those social cognitive theory-supported changes. Coaction (Johnson et al., 2014) was corroborated and its mechanisms partially indicated. Thus, well-tailored treatments can facilitate needed psychosocial changes as knowledge in that area continues to evolve through extensions of the present study and previous related research.

Although the field nature of this investigation was an advantage for practical applications of findings in future community-based applications with large-scale dissemination possibilities, there were also notable limitations. Beyond the need to replicate this research with larger and more diverse samples (e.g., with men; those with diabetes and/or eating disorders), potential confounders/limitations such as expectation/social support effects (e.g., the self-regulation-focused treatment had more in-person time with the instructors than the education-focused condition), reliance on self-reports, and volunteerism should be addressed. Also, longer timeframes are required to assess sustained effects. Because only participants who completed a moderate amount of exercise were included, and there was a difference in group sample sizes, some bias and lack of generalizability of findings was also likely.

Implications for Health Behavior Research

Ultimately, increased data on the array of psychosocial factors that explain weight loss, and the effects moderate amounts of exercise and treatment foci have on addressing them, should facilitate improved outcomes from (better-informed) behavioral obesity treatments. Social cognitive theory (Bandura,

1986, 2005) is an important paradigm for shaping behavioral treatment components, and research designs flowing from its tenets should remain relevant. It will also be imperative that ongoing research findings in the area are conferred into protocols in a manner where largescale application can be facilitated.

Discussion Questions

In what ways do changes in self-regulation and negative mood have implications for the behavioral treatment of obesity?

Ethical Approval

Institutional review board (IRB) approval and IRB-approved written informed consent was obtained from all participants prior to the start of study processes. Ethical mandates of the World Medical Association Declaration of Helsinki and the American Psychological Association were upheld throughout.

Conflict of Interests

The author has no conflicts of interest to declare.

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